FISHERY RESEARCH

SNAKE RIVER SOCKEYE SALMON CAPTIVE BROODSTOCK PROGRAM RESEARCH ELEMENT

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SNAKE RIVER SOCKEYE SALMON CAPTIVE BROODSTOCK PROGRAM RESEARCH ELEMENT

2001 Annual Project Progress Report

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EXECUTIVE SUMMARY

On November 20, 1991, the National Marine Fisheries Service listed Snake River sockeye salmon *Oncorhynchus nerka* as endangered under the Endangered Species Act of 1973. In 1991, the Shoshone-Bannock Tribes and Idaho Department of Fish and Game initiated the Snake River Sockeye Salmon Sawtooth Valley Project to conserve and rebuild populations in Idaho. Restoration efforts are focusing on Redfish, Pettit, and Alturas lakes within the Sawtooth Valley.

The first release of hatchery-produced juvenile sockeye salmon from the captive broodstock program occurred in 1994. The first anadromous adult returns from the captive broodstock program were recorded in 1999, when six jacks and one jill were captured at Idaho Department of Fish and Game's Sawtooth Fish Hatchery. In 2001, progeny from the captive broodstock program were released using four strategies: age-0 presmolts were released to all three lakes in October and to Pettit and Alturas lakes in July; age-1 smolts were released to Redfish Lake Creek, and hatchery-produced adult sockeye salmon were released to Redfish Lake for volitional spawning in September along with anadromous adult sockeye salmon that returned to the Sawtooth basin and were not incorporated into the captive broodstock program.

Kokanee population monitoring was conducted on Redfish, Alturas, and Pettit lakes using a midwater trawl in September. Only age-0 and age-1 kokanee were captured on Redfish Lake, resulting in a population estimate of 12,980 kokanee. This was the second lowest kokanee abundance estimated since 1990. On Alturas Lake age-0, age-1, and age-2 kokanee were captured, and the kokanee population was estimated at 70,159. This is a mid range kokanee population estimate for Alturas Lake, which has been sampled yearly since 1990. On Pettit Lake only age-1 kokanee were captured, and the kokanee population estimate was 16,931. This estimate is in the midrange of estimates of the kokanee population in Pettit Lake, which has been sampled yearly since 1992. We continue to have difficulty capturing age-0 kokanee in the midwater trawl on Pettit Lake.

Angler surveys were conducted on Redfish and Alturas lakes to estimate kokanee harvest and to estimate return to creel for hatchery rainbow trout planted in Alturas Lake. We failed to encounter any kokanee that had been harvested in 88 angler interviews conducted between May 26 and August 7, resulting in an estimated kokanee harvest of zero. On Alturas Lake, we again failed to encounter any harvested kokanee in 116 angler interviews, resulting in an estimated kokanee harvest of zero. We estimated that anglers harvested 9.5% of the 6,598 rainbow trout planted in Alturas Lake.

We estimated that 110 wild/natural and 9,616 hatchery-produced sockeye salmon smolts out-migrated from Redfish Lake in 2001. This was the lowest estimate of unmarked smolt out-migration since monitoring began in 1991. The trap on Redfish Lake Creek was operated from April 22 to June 6, 2001 to estimate out-migration. Mean travel times for PIT-tagged smolts from Redfish Lake Creek Trap to Lower Granite Dam was 10.3 days for wild/natural smolts and 10.6 days for hatchery-produced smolts. Based on cumulative unique PIT tag interrogations from Sawtooth basin traps to mainstem Snake and Columbia river dams, the Redfish Lake wild/natural smolts, Redfish fall direct presmolts group, and Alturas Lake fall direct presmolts recorded the highest detection rates.

In 2001, 65 hatchery-raised and 14 anadromous adult sockeye salmon were released to Redfish Lake for natural spawning. We observed 12 to 15 areas of excavation in the lake that were possible redds.

We monitored bull trout spawning on Fishhook Creek, a tributary to Redfish Lake, and on Alpine Creek, a tributary to Alturas Lake. This represented the fourth consecutive year that the index reaches have been surveyed on these two streams. Adult counts on Fishhook Creek were similar to previous years as were redd counts. On Alpine Creek, bull trout numbers were also similar to previous years, but the number of redds observed increased over previous years. We noted that redds counted during the first survey could become obscured before the final survey, indicating that the counts were not cumulative. We recommend marking redds during the first survey so that a total count can be obtained.

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PART 1—PROJECT OVERVIEW

Snake River sockeye salmon *Oncorhynchus nerka* were listed as endangered under the Endangered Species Act (ESA) by the National Marine Fisheries Service (NMFS) on November 20, 1991. Residual (nonmigratory) sockeye salmon were discovered in Redfish Lake and added to the listing in 1992.

When the petition for listing was filed in 1991, the presence of two populations of *O. nerka* (resident kokanee and anadromous sockeye salmon) in Redfish Lake complicated the decision to list the species as endangered. The population proposed for listing was the sockeye salmon population, an anadromous form of *O. nerka* that spawns on the shoals of the lake in October and November. Juvenile sockeye salmon spend one or two years in the lake before smolting and migrating to the Pacific Ocean. Adult sockeye salmon spend one, two, or three years in the ocean before returning to Redfish Lake to spawn. The resident form of *O. nerka,* (kokanee), spawns in Fishhook Creek, a tributary to Redfish Lake, in August and September and spends their entire life in Redfish Lake. A third life history form of *O. nerka* was discovered in Redfish Lake in 1992. This form, known as residual sockeye salmon, spawn with the anadromous sockeye salmon on the shoals of the lake in October and November and are genetically similar to the anadromous sockeye salmon. Residual sockeye salmon spend their entire life in Redfish Lake and their progeny spend one or two years in the lake before smolting and migrating to the ocean.

The decision to list Snake River sockeye salmon as endangered required that they meet the definition of a “species” as defined by the ESA. Waples (1991) defined “species” as it pertains to Pacific salmon. The definition of a species is interpreted to include any subspecies of fish or any distinct population segment of any species that interbreeds when mature. Two criteria must be met for a population to be considered an evolutionarily significant unit (ESU) and, therefore, a species. The population must be reproductively isolated, and it must represent an important component in the evolutionary legacy of the species. Reproductive isolation does not have to be absolute, but it must be strong enough to allow evolutionarily important differences to accrue in the different population units (Waples 1991).

Studies conducted after Snake River sockeye salmon were listed as endangered clarified the genetic relationships between anadromous sockeye salmon, residual sockeye salmon, and resident kokanee. Waples et al. (1997) stated that there were two distinct gene pools of *O. nerka* in Redfish Lake: one consisting of Redfish Lake kokanee, the other of anadromous and residual sockeye salmon. Because of the new information, the Snake River sockeye salmon ESU was defined to specifically exclude the Fishhook Creek kokanee population from ESA protection.

In Idaho, only the lakes of the upper Salmon River (Sawtooth basin) remain as potential sources of production for sockeye salmon. Historically, five Sawtooth basin lakes (Redfish, Alturas, Pettit, Stanley, and Yellowbelly) supported sockeye salmon (Bjornn et al. 1968). Current recovery efforts are focused on Redfish, Pettit, and Alturas lakes. Since 1991, 16 wild and 290 hatchery-produced adult Snake River sockeye salmon have returned to the Sawtooth basin from the Pacific Ocean.

The Idaho Department of Fish and Game (IDFG) is charged with the responsibility of reestablishing sockeye salmon runs to the Sawtooth basin, with emphasis placed on efforts to utilize endemic sockeye salmon stocks (IDFG 1992). The Snake River Salmon Sawtooth Valley

Project was started in 1991 as a cooperative effort between the Shoshone-Bannock Tribes (SBT), NMFS, and IDFG with the goal of conserving and rebuilding sockeye salmon populations in Idaho. Bonneville Power Administration (BPA) funds the project. Coordination and guidance for the recovery effort is provided by the Stanley Basin Sockeye Technical Oversight Committee (SBSTOC), composed of biologists representing the agencies involved in the recovery and management of Snake River sockeye salmon. Research and recovery activities associated with Snake River sockeye salmon are permitted under the ESA (NMFS Permit Nos. 1120, 1124, and 1233).

Idaho Department of Fish and Game participation in the Snake River Salmon Sawtooth Valley Project covers two areas of effort: 1) the sockeye salmon captive broodstock program, and 2) Sawtooth basin fisheries research. Although objectives and tasks from both components overlap and contribute to achieving the same goals, work directly related to the captive broodstock program appears under a separate cover (Kline et al. 2003). This report details fisheries research information collected between January 1 and December 31, 2001, including Sawtooth basin lakes kokanee population monitoring, sport fishery evaluation on Redfish and Alturas lakes, smolt out-migration monitoring and evaluation at lake outlets, telemetry studies of mature adult sockeye salmon released to Sawtooth basin lakes for natural spawning, and predator investigations in tributaries to Redfish and Alturas lakes.

PROJECT GOAL

The goal of the IDFG captive broodstock development and evaluation efforts is to recover sockeye salmon runs in Idaho waters. Recovery is defined as reestablishing sockeye salmon runs and providing for utilization of sockeye salmon and kokanee resources by anglers. The immediate project goal is to maintain this unique sockeye salmon population through captive broodstock technology and avoid species extinction.

PROJECT OBJECTIVES

1. Develop captive broodstocks from Redfish Lake anadromous sockeye salmon.

2. Determine the contribution hatchery-produced sockeye salmon make toward avoiding population extinction and increasing population abundance.

3. Describe kokanee population characteristics for Sawtooth basin lakes in relation to carrying capacity and broodstock program supplementation efforts.

4. Refine our ability to discern the origin of wild and broodstock sockeye salmon to provide maximum effectiveness in their utilization within the broodstock program.

5. Transfer technology through participation in the technical oversight committee process, providing written activity reports and participation in essential program management and planning activities.

STUDY AREA

Recovery efforts for Idaho sockeye salmon focus on Redfish, Alturas, and Pettit lakes in the Sawtooth Basin (Figure 1) located within the Sawtooth National Recreation Area. Basin lakes are glacial-carved, range in elevation from 1,985 m to 2,138 m (Table 1), and receive runoff from the Sawtooth and Smokey mountains. Lakes in the Sawtooth basin are considered oligotrophic. The lakes are part of the upper Salmon River watershed. The Salmon River flows into the Snake River, then the Columbia River, which drains into the Pacific Ocean. The Sawtooth basin is approximately 1,450 river km from the mouth of the Columbia River.

In addition to *O. nerka*, numerous native and nonnative fish reside in the study lakes and streams within the Sawtooth basin. Native fish present in Sawtooth basin waters include: chinook salmon *O. tshawytscha*, rainbow trout/steelhead *O. mykiss*, westslope cutthroat trout *O. clarki lewisi*, bull trout *Salvelinus confluentus*, sucker *Catostomus spp*., northern pikeminnow *Ptychocheilus oregonensis*, mountain whitefish *Prosopium williamsoni*, redside shiner *Richardsonius balteatus*, dace *Rhinichthys spp*., and sculpin *Cottus spp*. Nonnative species present in Sawtooth basin waters include lake trout *S. namaycush* (Stanley Lake only) and brook trout *S. fontinalis*. Rainbow trout are released into Pettit, Alturas, and Stanley lakes in the summer to increase sport-fishing opportunities. Sport fishing on Pettit, Alturas, and Stanley lakes is covered by Idaho's statewide general fishing regulations, which allow harvest of six trout per day (excluding bull trout which must be released if caught) and 12 kokanee per day with no seasonal closures (IDFG 2000). Sportfishing regulations on Redfish Lake restrict kokanee fishing/harvest to January 1 through August 7 to protect residual sockeye salmon. No trout have been stocked in Redfish Lake since 1992.

<u>Captive Broodstock Program Egg and Juvenile Supplementation</u>

All hatchery-produced sockeye salmon released to Sawtooth basin waters were adipose fin-clipped, and a portion were passive integrated transponder (PIT) tagged before release. One hundred fish from each release group were measured for fork length (1 mm) and weight (0.1 g) during PIT tagging prior to release.

In 2000, 137,731 sockeye salmon were released into Sawtooth basin waters from the captive broodstock program (Table 2). All presmolts released in 2000 were age-0 fish from brood year (BY) 1999. Redfish Lake received 48,051 presmolts released directly to the lake in October. All presmolts released to Redfish Lake were reared at the IDFG Sawtooth Fish Hatchery (SWT). Forty-six BY1997 hatchery-produced adults were released for volitional spawning directly into Redfish Lake in September. Ten of the hatchery-produced adult sockeye salmon (five males, five females) were reared at the IDFG Eagle Fish Hatchery (EAG), Eagle, Idaho. The remaining 36 hatchery-produced adult sockeye salmon were reared at the NMFS Manchester Marine Laboratory, Manchester, Washington. We were unable to determine sex at time of release. An additional 120 anadromous adult sockeye salmon (hatchery origin) were released into Redfish Lake in September (79 males, 41 females). Redfish Lake Creek received 148 PIT-tagged age-1 smolts (BY1998; reared at EAG) released directly into the stream.

Alturas Lake received 5,986 presmolts released directly into the lake in July (2,917 reared at EAG, and 3,069 reared at SWT) and another 6,003 in October 2000 (reared at SWT). Twenty-five hatchery-produced adult sockeye salmon (BY1997) reared at Manchester Marine Laboratory were released for volitional spawning directly into Alturas Lake on September 12.

We were unable to determine sex at time of release. Fifty-two anadromous adult sockeye salmon (36 males, 16 females) of hatchery origin were released into Alturas Lake in September.

Pettit Lake received 6,007 presmolts released directly to the lake in July (2,915 reared at EAG, and 3,092 reared at SWT). In October 2000, another 6,067 presmolts (reared at SWT) were released directly to the lake. Twenty-eight anadromous adult sockeye salmon (20 males, 8 females) of hatchery origin were released into Pettit Lake in September for volitional spawning. A total of 65,200 eyed-eggs (BY2000, 44,440 EAG and 20,760 Manchester Marine Laboratory) were planted in Pettit Lake in November.

In 2001, 120,150 sockeye salmon were released into Sawtooth basin waters from the captive broodstock program (Table 3). All presmolts released in 2001 were age-0 fish from BY2000. Redfish Lake received 41,529 adipose fin-clipped presmolts released directly to the lake in October and 41,474 adipose and left ventral fin-clipped presmolts reared in net pens and released to the lake in October. Presmolts released directly to the lake were reared at SWT; presmolts released to net pens were reared at EAG. Fifty-five hatchery produced adult sockeye salmon (BY1997) and 14 anadromous (hatchery-origin) adult sockeye salmon were released for volitional spawning directly to the lake in September (seven males and seven females). Alturas Lake received 6,123 presmolts released in July (3,059 reared at SWT and 3,064 reared at EAG) and another 5,990 presmolts in October (reared at SWT). Pettit Lake received 6,057 presmolts released in July (2,998 reared at SWT and 3,059 reared at EAG) and another 4,993 presmolts in October (reared at SWT). Redfish Lake Creek received 13,915 age-1 smolts (BY1999) reared at Oregon Department of Fish and Wildlife's Bonneville Fish Hatchery.

Table 1. Physical and morphometric characteristics of five study lakes located in the Sawtooth basin (Sawtooth Valley National Recreation Area), Idaho.

Surface Area (ha)	Elevation (m)	Volume ($m^3 \times 10^6$)	Mean Depth (m)	Maximum Depth (m)	Drainage Area (km^2)
		REDFISH LAKE			
615	1,996	269.9	44	91	108.1
		ALTURAS LAKE			
338	2,138	108.2	32	53	75.7
		PETTIT LAKE			
160	2,132	45.0	28	52	27.4
		STANLEY LAKE			
81	1,985	10.4	13	26	39.4
		YELLOWBELLY LAKE			
73	2,157	10.3	14	26	30.4

Table 2. Sockeye salmon releases made to Sawtooth basin waters in 2000.

Release Location	Strategy (Brood Year)	Release Date	Number Released	Marks	Number PIT Tagged[a]	Release Weight (g)	Rearing Location
Redfish Lake Creek smolt							
(downstream of trap)	(1998)	05/09/00	148	AD	148	2 58.8	Eagle Fish Hatchery
Redfish Lake presmolt							
(direct lake)	(1999)	10/11/00	48,051	AD	—	10.8	Sawtooth Fish Hatchery
Redfish Lake adult							
(boat ramp)	(1997)	09/05/00	36	—	—	985.0	Manchester Marine Laboratory
	(1997)	09/06/00	10	—	—	3,300.0	Eagle Fish Hatchery
	(1996)	09/06,07/00	120	—	—	1,500.0	Anadromous return
Alturas Lake presmolt							
(direct lake)	(1999)	07/31/00	2,917	AD/RV	—	8.5	Eagle Fish Hatchery
	(1999)	07/31/00	3,069	AD/LV	—	3.0	Sawtooth Fish Hatchery
	(1999)	10/11/00	6,003	AD	—	12.8	Sawtooth Fish Hatchery
Alturas Lake adult							
(boat ramp)	(1997)	09/05/00	25	—	—	994.0	Manchester Marine Laboratory
	(1996)	09/07/00	52	—	—	1,500.0	Anadromous return
Pettit Lake presmolt							
(direct lake)	(1999)	07/31/00	2,915	AD/RV	—	8.5	Eagle Fish Hatchery
	(1999)	07/31/00	3,092	AD/LV	—	3.0	Sawtooth Fish Hatchery
	(1999)	10/11/00	6,067	AD	—	13.9	Sawtooth Fish Hatchery
Pettit Lake adult							
(boat ramp)	(1996)	09/07/00	28	—	—	1500.0	Anadromous return
Pettit Lake eyed-egg							
(north side of lake)	(2000)	11/29,30/00	20,760	—	—	—	Manchester Marine Laboratory
	(2000)	11/29,30/00	44,440				Eagle Fish Hatchery

[a] Only the smolts for the 2001 release year were PIT tagged.

Table 3. Sockeye salmon releases to Sawtooth Basin waters for 2001.

Release Location	Strategy (Brood Year)	Release Date	Number Released	Marks	Number PIT tagged[a]	Release Weight (g)	Rearing Location
Redfish Lake Creek (below trap)	smolt (1999)	5/2/2001	13,915	AD/CWT	1,000	49.4	ODFW Bonneville Fish Hatchery
Redfish Lake (direct lake)	presmolt (2000)	10/8/2001	41,529	AD	0	10.8	Sawtooth Fish Hatchery
Redfish Lake (net pen)	presmolt (2000)	10/10/2001	41,474	AD/LV	0	30.0	Eagle Fish Hatchery
Redfish Lake	adult						
(boat ramp)	(1997)	9/9-10/2001	55	AD	0	2522.0	Manchester Marine Laboratory
	(1997)	9/10/2001	10	AD			anadromous return
	(1997)	9/11/2001	4	None			anadromous return
Alturas Lake (direct lake)	presmolt (2000)	7/27/2001	3,064	AD/LV	0	14.5	Eagle Fish Hatchery
	(2000)	7/31/2001	3,059	AD/RV	0	4.0	Sawtooth Fish Hatchery
	(2000)	10/9/2001	5,990	AD	0	14.0	Sawtooth Fish Hatchery
Pettit Lake (direct lake)	presmolt (2000)	7/27/2001	3,059	AD/LV	0	14.4	Eagle Fish Hatchery
	(2000)	7/31/2001	2,998	AD/RV	0	4.0	Sawtooth Fish Hatchery
	(2000)	10/9/2001	4,993	AD	0	15.4	Sawtooth Fish Hatchery

[a] Only smolts for the year 2001 release year were PIT tagged prior to release.

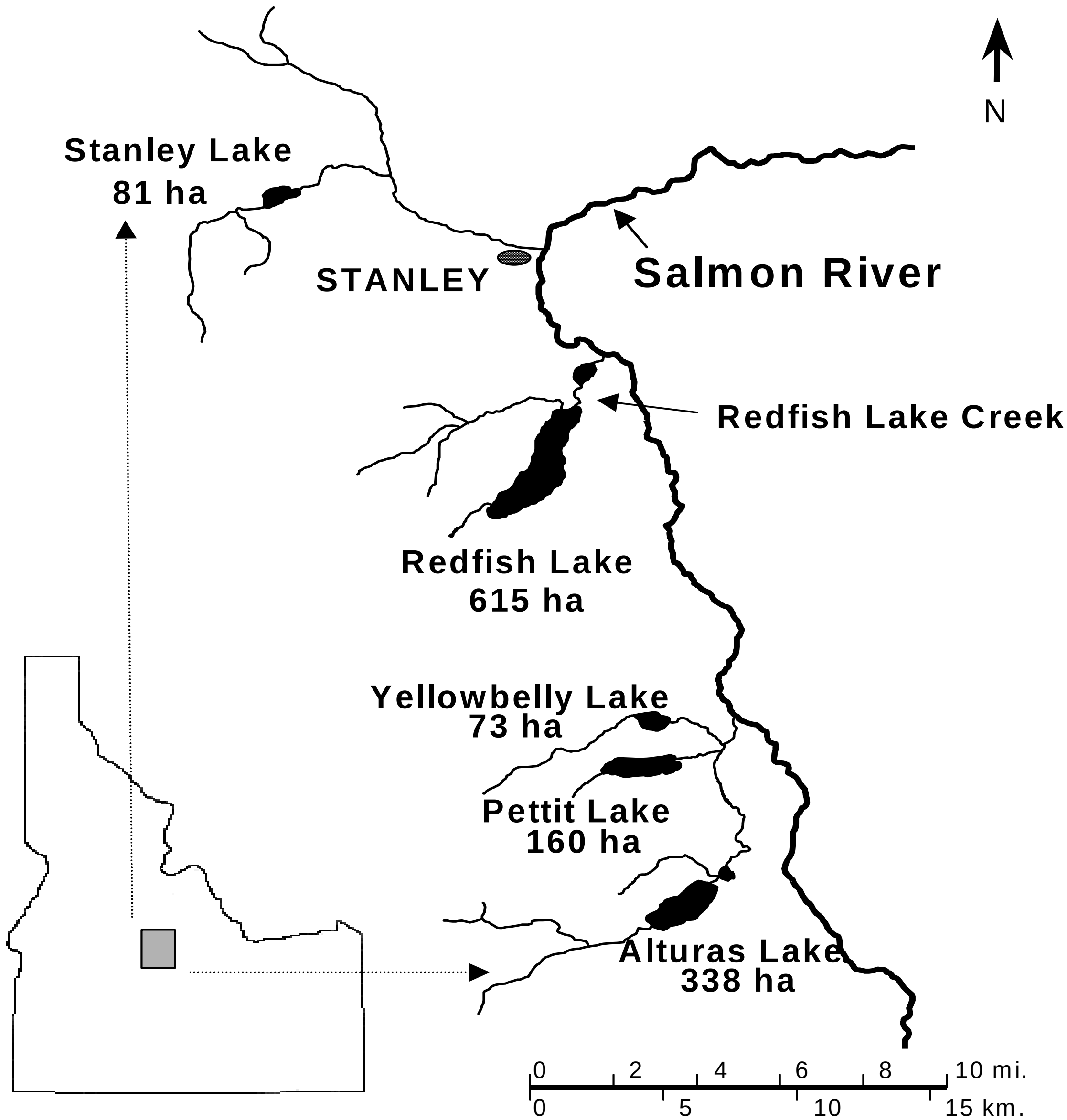

Figure 1. Location of Sawtooth basin in Idaho.

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PART 2—KOKANEE POPULATION MONITORING

INTRODUCTION

Understanding the dynamics of kokanee populations in the Sawtooth basin lakes is a vital part of Sockeye salmon restoration efforts. Knowledge of kokanee abundance coupled with limnology data (collected by the SBT) is necessary for making responsible decisions regarding supplementation of sockeye salmon juveniles from the captive broodstock program.

METHODS

To estimate kokanee abundance, density, and biomass in Sawtooth basin lakes, midwater trawling was conducted at night during the dark (new) phase of the moon in September. September was chosen so that spawning-age kokanee in Redfish and Alturas lakes would be in the tributaries and not sampled by the gear. In addition, juvenile kokanee that remain in basin lakes are tightly grouped during this period. Redfish, Pettit, and Alturas lakes were sampled September 17, 18, and 19. Trawling was performed in a stepped-oblique fashion as described by Rieman (1992) and Kline (1994). A minimum of four trawl transects were conducted per lake. Total kokanee abundance, density, and biomass were estimated using the TRAWL.WK1 spreadsheet for Lotus 1-2-3 developed by Rieman (1992). Abundance estimates generated by this program are extrapolations of actual trawl catch data to the total area of the lake at mid-depth in the observed *O. nerka* stratum. Density and biomass estimates generated by the program are extrapolations of catch data to total surface area. Whenever possible, we estimated abundance, density, and biomass by individual age class (assuming representation in the trawl).

Fork length (1 mm) and weight (0.1 g) were recorded for all trawl-captured kokanee. Sagittal otoliths and scales were removed from a subsample of kokanee and returned to the laboratory, where three readers aged them to determine length ranges for age classification. Scales were pressed into acetate before aging. Tissue samples were collected and sent to the University of Idaho's Hagerman Fish Culture Experiment Station for genetic analysis. Stomachs were removed and preserved for diet analysis by SBT biologists. Heads were removed and submitted to IDFG's Eagle Fish Health Lab for whirling disease testing.

RESULTS

Redfish Lake

September trawl catch (six transects, Appendix A) included 16 wild/natural kokanee, zero hatchery-produced sockeye salmon, zero redside shiners, and two sculpin. Kokanee abundance was estimated at 12,980 fish (95% CI $\pm$ 12,080). Density and biomass were estimated at 21.1 fish/ha and <0.1 kg/ha (Table 4). Only age-0 and age-1 kokanee were captured in the trawl on Redfish Lake (Table 5).

Alturas Lake

September trawl catch on Alturas Lake (four transects, Appendix A) collected 116 wild/natural kokanee and zero hatchery-produced sockeye salmon. We estimated kokanee abundance, density, and biomass at 70,159 (95% CI $\pm$ 18,642) fish, 207.6 fish/ha, and 2.4 kg/ha (Table 4). Age-0, age-1, and age-2 kokanee were captured in the trawl. Age-1 fish were most numerous and contributed 86% of the biomass (Table 5).

Pettit Lake

September trawl catch on Pettit Lake (four transects, Appendix A) collected 12 wild/natural kokanee, two hatchery-produced sockeye salmon, and four redside shiners. One of the sockeye salmon was adipose and left ventral fin-clipped, and the other was adipose and right ventral fin-clipped, identifying these fish as sockeye salmon presmolts from the summer release. We estimated kokanee abundance, density, and biomass at 16,931 (95% CI $\pm$ 7,566) fish, 105.8 fish/hectare, and 6.1 kg/ha respectively (Table 4). Only age-1 fish were captured in the trawl (Table 5).

Stanley Lake

We trawled four transects on Stanley Lake and captured 12 kokanee and 3 redside shiners. Kokanee abundance was estimated at 2,472 fish (95% CI $\pm$ 2,872). Kokanee density and biomass were estimated at 35.5 fish/ha and 0.2 kg/ha (Table 4). Only age–1 kokanee were captured in the trawl (Table 5).

DISCUSSION

Redfish Lake

Although Redfish Lake has the largest surface area of the three lakes studied, spawning habitat is thought to limit kokanee population abundance. Because kokanee spawning is limited to a short reach of Fishhook Creek, the kokanee population has been relatively stable from 1990 to 1999 and has maintained moderate densities compared to the other lakes in the basin. Prior to 2000, year-to-year kokanee population numbers varied less than 40%. Abundance decreased in 2000 to the lowest recorded value (10,268). In 2001, we documented only a slight increase from the all time low documented in 2000. Following the documented reduction of kokanee biomass in 2000, we theorized that the reduced grazing pressure would allow zooplankton biomass to increase. According to data from the SBT (May 2002 SBSTOC minutes) mean summer zooplankton biomass (June to October) in Redfish Lake reached an all-time high during the summers of 2000 and 2001. *Daphnia sp.* and *Holopedium sp.* contributed the majority of the increase in biomass to total zooplankton numbers. This two-year increase in zooplankton biomass suggests grazing pressure from the resident kokanee population may control zooplankton biomass.

Alturas Lake

Abundance of kokanee in Alturas Lake has been highly variable since monitoring began in 1990. We believe that abundant spawning habitat for kokanee in Alturas Lake Creek contributes to the fluctuating kokanee abundance observed (over 120,000 fish in 1990 to less than 6,000 fish in 1994; Table 4). The 2001 estimate of abundance (70,159) is substantially lower than the previous year's estimate of 125,462. This decrease is due in part to the low spawner escapement of only 827 adult kokanee during the fall of 2000, compared to a spawner escapement of 8,334 adults in 1999. This had a large effect on age-0 recruitment (D. Taki, Shoshone-Bannock Tribes, personal communication).

The high kokanee abundance observed in 2000 was expected to have a detrimental effect on the zooplankton resources of the lake for several years. Based on past observations of high kokanee abundance, all zooplankton except *Bosmina sp.* were scarce for several years following a high kokanee abundance observed in 1990 and 1991. It appears from the summer 2001 data that a gradual decline in zooplankton biomass is occurring. Cyclopoid copepods, *Holopedium sp.,* and *Daphnia sp.* biomass were at a four-year low (SBSTOC minutes March 2002). If the pattern continues, we expect to see reduced kokanee survival for the next several years. Reductions in zooplankton biomass will also reduce the desirability of the lake for sockeye salmon restoration activities.

Pettit Lake

Since monitoring began in 1992, Pettit Lake has exhibited the greatest relative fluctuation in kokanee numbers (maximum to minimum range) of the three lakes studied. Kokanee abundance increased from 1992 (3,009) to 1996 (71,654), then declined in 1997 (21,730; Table 4). The population increased steadily from 1997 to 2000, reaching a high of 40,559. During 2001, we documented a sharp decline in kokanee abundance to 16,931 fish.

We suspect that the reported decrease in kokanee abundance may be the result of bias associated with midwater trawling. For the last three years, we have failed to capture age-0 kokanee in Pettit Lake during our trawl surveys. However, age-1 and older kokanee have been captured annually. This suggests that age-0 kokanee are present but not sampled by our gear. One possible explanation for this is that age-0 kokanee are utilizing near-shore habitat that we do not sample during our trawl surveys. Zooplankton biomass in Pettit Lake has been increasing steadily since June 2000, and lake rearing conditions are currently favorable for kokanee. These data support our assumption that the reported reduction in kokanee abundance is most likely a result of sampling error.

Stanley Lake

Kokanee abundance in Stanley Lake appears to be stable. Stanley Lake is only surveyed every other year for kokanee abundance. The 2001 abundance was similar to abundances recorded from 1992 through 1995. Spawner escapement during 2000 and 2001 were the two highest on record with over 5,000 adults estimated to have spawned. These two large spawning years may provide substantial increases in kokanee abundance over the next two years.

Table 4. Estimated kokanee population, density (fish/ha), and biomass (kg/ha) in four Stanley Basin lakes, 1990 to 2001.

Date	Population (± 95% CI)	Density (fish/ha)	Biomass (kg/ha)
	Redfish Lake (615 surface hectares)		
9/17/01	12,980 (12,080)	21.1	<0.1
9/25/00	10,268 (5,675)	16.7	<0.1
9/8/99	42,916 (13,177)	69.7	0.9
9/21/98	31,486 (11,349)	51.2	1.8
9/02/97	55,762 (13,961)	90.7	2.5
9/10/96	56,213 (28,102)	91.4	2.8
9/26/95	61,646 (27,639)	100.2	4.4
9/06/94	51,529 (33,179)	83.8	1.4
9/17/93	49,628 (—)*	80.7	1.6
9/29/92	39,481 (10,767)	64.2	1.0
8/20/90	24,431 (11,000)	39.7	0.8
	Alturas Lake (338 surface hectares)		
9/19/01	70,159 (18,642)	207.6	2.4
9/25/00	125,462 (27,037)	371.0	2.1
9/9/99	56,675 (43,536)	167.7	0.4
9/23/98	65,468 (34,284)	193.7	1.4
9/04/97	9,761 (4,664)	28.9	2.1
9/12/96	13,012 (3,860)	38.5	1.4
9/25/95	23,061 (9,182)	68.2	1.7
9/07/94	5,785 (6,919)	17.1	0.4
9/17/93	49,037 (13,175)	145.1	2.6
9/25/92	47,237 (61,868)	139.8	2.4
9/08/91	125,045 (30,708)	370.0	3.9
8/19/90	126,644 (31,611)	374.7	3.3
	Pettit Lake (160 surface hectares)		
9/17/01	16,931 (7,566)	105.8	6.1
9/28/00	40,559 (11,717)	253.5	10.2
9/10/99	31,422 (21,280)	196.4	6.3
9/22/98	27,654 (8,764)	172.8	9.7
9/03/97	21,730 (11,262)	135.8	5.1
9/11/96	71,654 (9,658)	447.8	15.3
9/24/95	59,002 (15,735)	368.8	14.7
9/08/94	14,743 (3,683)	92.1	3.1
9/18/93	10,511 (3,696)	65.7	0.8
9/27/92	3,009 (2.131)	18.8	2.5
	Stanley Lake (81 surface hectares)		
9/17/01	2,472 (2,872)	35.5	0.2
9/24/98	14,936 (7,391)	184.4	5.0
9/27/95	1,021 (702)	12.6	0.2
9/07/94	2,694 (913)	33.3	0.4
9/16/93	1,325 (792)	16.4	0.5
8/28/92	2,117 (1,592)	26.1	0.2

*Confidence limits not calculated - single transect estimate.

Table 5. Estimated 2001 kokanee abundance, density (fish/ha), and biomass (kg/ha) by age class in Sawtooth basin lakes.

	Age-0	Age-1	Age-2	Age-3	Total
		Redfish Lake (615 surface ha)			
# captured	15	1	0	0	16
Length range (mm)	0-90	91-110	—	—	—
Mean length (mm)	72.5	107	—	—	—
Mean weight (g)	3.8	12.2	—	—	—
Abundance	12,170	810	—	—	12,980
95% CI High	24,141	2,429	—	—	25,060
95% CI Low	200	0	—	—	900
Density (fish/ha)	20	1	—	—	21
Biomass (kg/ha)	0.08	0.02	—	—	0.09
		Alturas Lake (338 surface ha)			
# captured	8	52	43	13	116
Length range (mm)	1-60	61-105	106-140	141-175	—
Mean length (mm)	51.3	82.9	120.7	155.3	—
Mean weight (g)	1.1	5.2	15.5	30.5	—
Abundance	8,468	29,032	26,612	6,048	70,159
95% CI High	1,1591	42,574	38,628	9,172	51,517
95% CI Low	5,344	15,489	14,597	2,925	88,801
Density (fish/ha)	25	86	79	18	208
Biomass (kg/ha)	0.04	0.49	1.30	0.57	2.40
		Pettit Lake (160 surface ha)			
# captured	0	1	0	29	30
Length range (mm)	—	61-90	—	161-195	—
Mean length (mm)	—	86.0	—	178.7	—
Mean weight (g)	—	7.4	—	58.9	—
Abundance	—	559	—	16,372	16,931
95% CI High	—	1678	—	23,976	33,862
95% CI Low	—	0	—	8,769	0
Density (fish/ha)	—	3	—	102	106
Biomass (kg/ha)	—	0.03	—	6.03	6.10
		Stanley Lake (81 surface ha)			
# captured	0	12	0	0	12
Length range (mm)	—	51-110	—	—	—
Mean length (mm)	—	80.3	—	—	—
Mean weight (g)	—	6.0	—	—	—
Abundance	—	2,472	—	—	2,472
95% CI High	—	5,343	—	—	5,343
95% CI Low	—	0	—	—	0
Density (fish/ha)	—	31	—	—	31
Biomass (kg/ha)	—	0.18	—	—	0.18

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PART 3—REDFISH AND ALTURAS LAKES SPORT FISHERY INVESTIGATIONS

INTRODUCTION

The kokanee fishery on Redfish Lake was closed in 1993 due to the presence of ESA listed residual sockeye salmon but was reopened in 1995 (NMFS Permit 1233). The kokanee fishery was opened based on the recommendation of the SBSTOC to reduce kokanee competition with sockeye salmon by removing spawning age kokanee through angler harvest. Permit 1233 (NMFS) requires IDFG to monitor angler harvest of listed sockeye salmon in Redfish Lake during the kokanee fishing season. The kokanee season on Redfish Lake closes on August 7, because mature kokanee begin their spawning run up Fishhook Creek at this time, while residual sockeye salmon remain in the lake.

The roving creel survey on Redfish Lake was designed to estimate total kokanee harvest on Redfish Lake and to collect tissue samples for genetic analysis from angler-harvested kokanee. The tissue samples were analyzed by the University of Idaho's Center for Salmonid and Freshwater Species At Risk to estimate the number of residual sockeye salmon harvested incidental to the kokanee fishery.

METHODS

Redfish Lake

A roving creel survey was conducted from May 26 through August 7, 2001 (kokanee harvest closes on August 7 to protect residual sockeye salmon). The creel census was stratified by 14 d intervals, broken into weekday and weekend day types and morning (0800 to 1400) and evening (1400 to 2000) periods. Angler counts were conducted two weekdays and one weekend day during each week of the 14 d interval. On each angler count day, the number of boats and bank anglers were counted for each day period (morning and evening strata) from a boat. Angler count dates were selected randomly, and count times were selected systematically. Angler interviews were conducted following the completion of each count. Anglers were asked how many fish they had harvested and/or released by species, how many hours they had fished, and the type of gear they used. Fin clips were taken from all creeled kokanee that were checked by creel survey personnel. Fin clips were stored in Lysis buffer solution and delivered to University of Idaho personnel for DNA analysis. Creel data were analyzed using the Creel Census System computer program developed by McArthur (1992) and used to estimate angler effort, catch rates, and harvest.

Alturas Lake

A roving creel survey of Alturas Lake was conducted from May 26 through September 3, 2001 following the same procedures described above for Redfish Lake. There is no kokanee fishing/harvest closure on Alturas Lake.

RESULTS

Redfish Lake

In 2001, we contacted 87 angler parties (88 individual anglers) on Redfish Lake. Residents made up 67% of those interviewed. Most anglers used lures (55%) followed by bait (41%), and only a small amount used flies (4%). Total angler effort was estimated at 2,391 hours (95% CI ± 474). Bank anglers expended more effort than boat anglers (Table 6). The average fishing trip lasted 1.9 hours.

The season catch rate for all fish (harvested and released) was 0.45 fish/hour. Season catch rates (all fish) were higher for weekends (0.60 fish/hour) than for weekdays (0.40 fish/hour; Table 7). Kokanee catch rates (caught and released) averaged 0.06 fish/hour for weekdays and weekends. Bull trout catch rates averaged 0.27 fish/hour (IDFG regulations prohibit harvesting bull trout). Other fish (brook trout, redside shiners, mountain whitefish, northern pikeminnow) accounted for catch rates of 0.11 fish/hour for the season.

Total number of fish caught (harvested and released) at Redfish Lake was estimated at 1,695 (95% CI ± 633; Table 8). The majority of fish (97%) caught were released. We encountered no harvested kokanee. Bull trout and kokanee comprised the majority of the fish released by anglers.

Alturas Lake

In 2001, we contacted 116 angler parties (120 individual anglers) on Alturas Lake. Residents made up 59% of those interviewed. Most of the angling was done with bait (67%) followed by lures (31%), and only a small amount of fishing occurred with flies (3%). Total angler effort was estimated at 2,059 hours (95% CI ± 484), and bank anglers fished more than boat anglers (Table 6). The average angling trip lasted 2.6 hours.

The season catch rate for all fish (harvested and released) was 0.63 fish/hour (Table 7). Seasonal catch rates (all fish) were higher for weekends (0.99 fish/hour) than for weekdays (0.49 fish/hour). Kokanee catch rates (caught and released) averaged 0.03 fish/hour for the season. Bull trout catch rates averaged 0.17 fish/hour. Catch rates for rainbow trout were higher on weekends (0.71 fish/hour) than weekdays (0.25 fish/hour). Other fish species (brook trout, redside shiners, mountain whitefish, northern pikeminnow) accounted for catch rates of less than 0.05 fish/hour for the season.

The total number of fish caught (harvested and released) at Alturas Lake was estimated at 1,772 fish (95% CI ± 606; Table 8). Of the 6,598 rainbow trout planted in Alturas Lake, anglers harvested approximately 9.5%. Again, we encountered no harvested kokanee during angler interviews.

DISCUSSION

Redfish Lake

We assume that kokanee anglers on Redfish Lake primarily remove adults of spawning age from the population. Kokanee become more susceptible to fishing gear and harvest by anglers as they increase in age and length. Removal of spawning-age kokanee by sport harvest helps to reduce total egg deposition, potentially decreasing kokanee recruitment and competition with sockeye salmon in future years. Kokanee escapement to Fishhook Creek during the 2001 spawning season was estimated at 5,853 fish (D. Taki, Shoshone-Bannock Tribes, personal communication). However, in 2001 we did not encounter any kokanee in the creel, resulting in an estimated harvest of zero kokanee from Redfish Lake.

Alturas Lake

Despite over 116 angler contacts, we did not encounter kokanee in the creel on Alturas Lake. Seasonal catch rates on Alturas Lake for kokanee were similar to the 2000 season of 0.03 fish/hour, so it is unlikely that the lack of harvest can be attributed to lack of availability. We do not have any information on size of the kokanee being caught on Alturas Lake, so the kokanee may not be a desirable size for harvest. The spawner escapement during 2001 on Alturas Lake was estimated at only 145 kokanee (October 2001 SBSTOC notes).

Table 6. Estimated angler effort for the 2001 fishing season on Redfish and Alturas lakes.

	Boat	Bank	Tube	Total
Redfish Lake				
Hours fished	1,002	1,332	57	2,391
± 95% CI	262	386	85	474
Alturas Lake				
Hours fished	969	1,520	22	2,509
± 95% CI	291	385	43	484

Table 7. Catch rates (fish/hour) for summer 2001 on Redfish and Alturas lakes categorized by day type and species.

	Kokanee			Bull Trout	Rainbow Trout		Other		All Fish		
Day Code	Kept	Released	Combined	Released	Kept	Released	Kept	Released	Kept	Released	Combined
Redfish Lake											
Weekday	0.00	0.07	0.07	0.17	0.00	0.02	0.00	0.13	0.00	0.40	0.40
Weekend day	0.00	0.04	0.04	0.50	0.00	0.00	0.02	0.04	0.03	0.56	0.60
Season average	0.00	0.06	0.06	0.27	0.00	0.02	0.00	0.11	0.01	0.45	0.45
Alturas Lake											
Weekday	0.00	0.01	0.01	0.16	0.13	0.12	0.00	0.07	0.13	0.36	0.49
Weekend Day	0.00	0.07	0.07	0.19	0.64	0.07	0.00	0.02	0.64	0.35	0.99
Season average	0.00	0.03	0.03	0.17	0.28	0.10	0.00	0.05	0.28	0.36	0.63

Table 8. Estimated number of fish harvested and released on Redfish and Alturas lakes during the summer of 2001.

	Harvested			All Fish		
	Kokanee	Rainbow Trout	Other	Released	Harvested	Combined
Redfish Lake						
Number of fish	0	0	35	1,647	47	1,695
95% CI	0	0	70	330	75	633
Alturas Lake						
Number of fish	0	631	0	1,140	631	1,772
95% CI	0	442	0	201	442	606

LITERATURE CITED

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PART 4—SOCKEYE SALMON SMOLT MONITORING AND EVALUATION

INTRODUCTION

Monitoring overwinter survival and out-migration of sockeye salmon smolts plays an important role in restoration efforts. Trapping conducted on the lake outlet streams provides an opportunity to gain valuable information on timing of out-migration and smolt sizes. Out-migrant monitoring provides an opportunity to monitor natural production of sockeye salmon in the lake and evaluate the success of different release strategies. This information allows us to make informed decisions regarding the disposition of future captive broodstock progeny.

METHODS

Redfish Lake Creek Trap

The out-migrant trap on Redfish Lake Creek (RLCTRP) is used to estimate numbers of wild/natural sockeye salmon smolts migrating from Redfish Lake and to monitor and estimate smolt production from different hatchery release strategies. The trap is located 1.4 km downstream from the lake outlet at a permanent weir site and was operated from April 22 to June 6, 2001. The trap functions as a juvenile trap and with only minor modifications an adult trap (Bjornn et al. 1968; Craddock 1958). The trap contains nine bays, five of which are fitted with juvenile trap boxes. Personnel from IDFG checked the trap twice daily.

All sockeye salmon smolts captured at RLCTRP were anesthetized in buffered MS-222 (tricaine methanesulfonate), measured for fork length (1 mm) and weight (0.1g), and scanned for passive integrated transponder (PIT) tags. Hatchery-produced sockeye salmon smolts captured at the trap originated primarily from an October 2000 release of 48,051 age-0 presmolts.

To estimate trapping efficiency, all wild/natural sockeye salmon smolts, determined by presence of an adipose fin, and up to 20 hatchery-produced sockeye salmon smolts per day were PIT tagged and released approximately 250 m upstream of the weir one-half hour after sunset. Flow-through live boxes with locking lids were used to hold fish until the evening release.

Trapping efficiencies were calculated for one time period for wild/natural sockeye salmon smolts and three time periods for hatchery-produced sockeye salmon smolts. Intervals were selected based on stream discharge similarities and the number of marked smolts released upstream of the weir that were available for recapture. Out-migrant run size and 95% confidence intervals were estimated using maximum likelihood and profile likelihood estimators (Wu and Steinhorst 2000). Smolt out-migration estimates were generated separately for wild/natural and hatchery-produced sockeye salmon smolts.

Petit and Alturas Lakes

Sockeye salmon smolt trapping and PIT tagging on Pettit Lake Creek and Alturas Lake Creek is performed by SBT. The out-migrant trap on the Salmon River at the Sawtooth Fish Hatchery is located downstream from Pettit and Alturas lakes. The trap was operated in 2001, but no attempt was made to develop an estimate of sockeye salmon smolt out-migration at this location.

Mainstem Snake and Columbia River Dams

Sockeye salmon smolt out-migration variables (travel time and date of arrival) were evaluated using PIT tag interrogation data collected at lower Snake and Columbia river dams with fish bypass and PIT tag detection facilities—Lower Granite (LGR), Little Goose (LGJ), Lower Monumental (LMN), and McNary (MCN) dams. The PIT tag interrogation data for mainstem Snake and Columbia river dams was retrieved from the Columbia River Basin PIT Tag Information System. Tagged to untagged ratios of smolts observed at Sawtooth basin trap locations were used to expand the number of PIT tag interrogations to derive a total out-migration estimate for presmolt release groups at LGR. Total wild/natural and hatchery-produced smolt out-migration was estimated using the known number of PIT tags released and the expanded number of PIT tags detected at LGR. Daily collection efficiency (DCE) (Sandford and Smith 2002) estimated for chinook salmon smolts was used to expand estimates of PIT tag interrogations for sockeye salmon smolts migrating past LGR. Daily collection efficiency takes into account the effect of spill on fish guidance efficiency. Median travel times to downstream dams with fish detection facilities were calculated for wild/natural and hatchery-produced sockeye salmon smolts. Distribution of arrival times for PIT-tagged fish at LGR were compared for wild/natural and hatchery-produced progeny (by release strategy) using two-sample Kolmogorov-Smirnov tests (α = 0.10) (Sokal and Rohlf 2000). Chi-square tests with Yates continuity correction (α = 0.10) were used to compare cumulative unique PIT tag interrogations from out-migrant traps to LGR, LGJ, LMN, and MCN between release strategies (Zar 1984).

A priori power analyses for Chi-square tests were performed to determine PIT tag sample sizes needed for comparisons (Cohen 1988). Using a range of values for overwinter survival, out-migration, and cumulative unique interrogations at mainstem Snake and Columbia river dams and a desired power of 0.80 at α = 0.10, it was estimated that a minimum of 850 fish in each presmolt release needed to be PIT tagged to have adequate sample size at downstream collection facilities.

RESULTS

Redfish Lake Creek Trap

A total of 9,726 sockeye salmon smolts (40 wild/natural and 4,119 hatchery-produced) were trapped during the 2001 out-migration season (Figure 2). Fork-length of wild/natural and hatchery-produced sockeye salmon smolts captured averaged 114 mm (range 99 mm to 132 mm; Figure 3) and 116 mm (range 88 mm to 147 mm; Figure 4). We estimated that 20% of the wild/natural out-migrants were age-2 smolts. Hatchery-produced out-migrants were predominantly age-1.

Total wild/natural sockeye salmon smolt out-migration was estimated using a single season efficiency interval. Forty wild/natural smolts were handled in 2001. Thirty-nine of these fish were marked and released upstream from the weir to estimate trapping efficiency. Overall trapping efficiency for wild/natural smolts was estimated at 36%. Total wild/natural sockeye smolt out-migration was estimated at 110 (95% CI 71 to 189; Table 9).

To estimate total hatchery-produced sockeye salmon smolt out-migration, the trapping season was divided into three periods of similar discharge. Trapping intervals ran from April 22 to May 3, May 4 to May 28, and May 29 to June 6. A total of 4,119 hatchery-produced smolts were handled in 2001. Of those 4,119 smolts, 1,390 were marked and released upstream of the weir to estimate trap efficiency. Trap efficiency was estimated at 69%, 45%, and 24% for the three trapping intervals. Total hatchery-produced smolt out-migration was estimated at 9,616 (95% CI 9,003 to 10,307: Table 9). This out-migration represents a 20% overwinter survival and out-migration for presmolts released in fall of 2000.

Mainstem Snake and Columbia River Dams

We estimated smolt out-migration success to LGR by release strategy using PIT tag interrogation data (Table 10; Appendix B). Estimates reflect numbers of smolts passing LGR adjusted for FGE (Appendix C). Redfish Lake had two groups of smolts for which estimates of out-migration were made: wild/natural and direct fall presmolt release. Numbers of wild/natural and direct fall release smolts passing LGR were estimated at 33 and 2,692, respectively. For the Pettit Lake release groups, eight of the SWT summer presmolts, zero of the EAG summer presmolts, and 265 of the SWT fall release presmolts were estimated to have passed LGR. For the Alturas Lake release groups, 219 of the Sawtooth summer presmolts, 14 of the Eagle summer presmolts, and 1,448 of the Sawtooth fall release presmolts were estimated to have passed LGR.

Median travel times for PIT-tagged smolts were recorded from Sawtooth basin trap sites to LGR, LGJ, LMN, and MCN (Table 11). Median travel times to LGR for Redfish Lake wild/natural and hatchery-produced sockeye salmon smolts were 10.3 days and 10.6 days, respectively. Significant differences in the distribution of arrival times at LGR were detected for all comparisons with Bonneville smolts released at Redfish Lake Creek trap, between the Redfish Lake fall presmolt group and all other presmolt release groups, and between the Alturas and Pettit lakes fall presmolt groups (Table 12).

Cumulative unique PIT tag detections were compared by group from Sawtooth basin trap sites to downstream interrogation facilities (Table 13). Three smolt groups from Redfish Lake were used in the comparisons (wild/naturals, fall direct presmolt, and Redfish Lake Creek smolt). The summer release groups in Alturas and Pettit lakes overwintered and out-migrated at low rates. Due to the small sample size, no comparisons were made. The Redfish Lake wild/natural smolts recorded the highest detection rates of all groups, but detection rates were not significantly higher than the Redfish or Alturas lakes fall presmolt groups (Table 13). The Redfish Lake Creek smolt group and the Pettit Lake fall presmolt group recorded significantly lower detection rates than all other groups (Table 13).

DISCUSSION

Redfish Lake Creek Trap

Beginning in 1998, presmolts destined for direct release back to Sawtooth basin lakes have been reared at Sawtooth Fish Hatchery (SWT). The 2001 out-migration year is the third opportunity to evaluate presmolts reared at Sawtooth and released to the lakes to overwinter and out-migrate. Overwinter survival of presmolts reared at SWT and released to Redfish Lake in the fall was 44% for the 1998 release, 29% for the 1999 release, and 20% for the 2000 release (Hebdon et al. 2000; Hebdon et al. 2002). The factors controlling decline in overwinter survival and out-migration are poorly understood. What is clear is that survival of fall presmolts is highly variable among years despite similar early rearing history.

Age-2 smolts are well documented in the Redfish Lake sockeye salmon population (Bjornn et al. 1968). We estimated that 20% of the wild/natural smolts passing RLCTRP in 2001 were age-2. During the 11-year study beginning in 1956, Bjornn et al. (1968) noted that for six out of the 11 years the out-migration was dominated by age-1 smolts. Age-2 smolts made up 2% to 77% of the total out-migration over the course of the early monitoring effort. Age-2 smolts are common in many other sockeye lakes, although the reasons for the additional freshwater residence time are unclear (Burgner 1991).

In 1998, there were no natural releases (eyed-eggs or mature adults) from the captive broodstock program that would have produced unmarked age-1 smolts in 2000; therefore, the 150 unmarked age-1 smolts should be from residual sockeye spawning that occurred in 1998. Wild/natural smolt production increased drastically in 1998 and 1999 following a 300-smolt out-migration in 1997. This increase was attributed to eyed-egg and mature adult releases. The decline in wild/natural production in absence of eyed-egg or mature adult releases provides further evidence that the increases observed in 1998 and 1999 were the result of one of the natural release options. Further evaluations should be focused on partitioning unmarked smolt production between the two natural release options.

Mainstem Snake and Columbia River Dams

We used estimates of survival to LGR as another method of evaluating success of progeny released from the captive broodstock program. This method should be continued, but the results should be viewed carefully in making future release decisions due to the multitude of factors that affect detections of PIT-tagged sockeye salmon. There are no estimates of daily collection efficiencies for sockeye salmon smolts at Lower Granite Dam; because of this lack of data, we must use caution and not overemphasize these results because of the possible difference between species. Date of smolt arrival can also affect the probability of a PIT-tagged fish being detected. For example, during the 2000 out-migration year, PIT-tagged sockeye salmon smolts were detected between May 1 and July 9. Both flow and percent of flow as spill during the period of sockeye salmon smolt out-migration varied widely, and collection efficiency varied accordingly. This resulted in a greater chance for the detection of a PIT-tagged smolt in July (little or no spill) compared to June (with 25 to 49% spill). Daily collection efficiencies partially correct for the changes in the probability of detection.

Cumulative unique PIT tag interrogations are another measure of smolt survival from release to LGR. Fish detected at facilities downstream of LGR first had to successfully pass LGR, so cumulative unique interrogations represent a minimum actual survival to LGR. During the 2001 out-migration, the Pettit Lake fall direct presmolt group recorded the lowest interrogation rates for the three direct presmolt release groups. Summer release groups from both Pettit and Alturas lakes recorded low overwinter survival and out-migration to Sawtooth basin traps, which resulted in very few smolts out-migrating to LGR for use in comparisons. We suspect that overwintering conditions in the lakes will affect a smolt's "fitness" and ability to survive out-migration, which could affect interrogation rates. This may explain the reduced interrogation rates of the Pettit Lake fall group. Currently we are working with the University of

Idaho to determine if total body lipid content of smolts captured at Sawtooth basin trap sites can be correlated with interrogation rates downstream.

Table 9. Mark recapture data for sockeye salmon smolts captured at the Redfish Lake Creek Trap (by efficiency periods) from April 22 to June 06, 2001. Data are organized by efficiency period.

				Total
Wild/natural smolts				
Dates		4-22 to 6-06		—
Trap efficiency		0.36		—
Marked		39		—
Recaptured		14		—
Total handled		40		—
Estimated total		110		110
95% CI upper bound		189		189
95% CI lower bound		71		71
Hatchery-produced smolts				
Dates	4-22 to 5-3	5-4 to 5-28	5-29 to 6-06	—
Trap efficiency	0.69	0.45	0.24	—
Marked	66	1,067	257	—
Recaptured	45	482	61	—
Total handled	130	3,687	302	—
Estimated total	189	8,158	1,269	9,616
Upper bound	234	8,768	1,634	10,307
Lower bound	160	7,618	1,010	9,003

Table 10. Summary of 2001 sockeye salmon smolt out-migration information (by release strategy) at trap locations and at Lower Granite Dam (LGR). Rearing locations are abbreviated as follows: IDFG Sawtooth Fish Hatchery (SWT), IDFG Eagle Fish Hatchery (EAG), Oregon Department of Fish and Wildlife's Bonneville Fish Hatchery (BON).

Release Strategy (Rearing Location)	Total*	Number Tagged**	% Tagged	Estimated At Trap	Overwinter Survival At Trap	Estimated PIT Tags At LGR***	% PIT Tags From Traps To LGR	Estimated At LGR	% At LGR From Release
Redfish Lake									
Wild/natural smolt	—	39	35.5%	110	—	12	30.4%	33	—
Redfish Lake Creek Smolt (BON)	13,915	1,000	7.2%	13,915	—	142	14.2%	1,969	—
Fall presmolt (SWT)	48,051	1,390	14.5%	9,616	20.0%	389	28.0%	2,692	5.6%
Alturas Lake									
Fall presmolt (SWT)	6,003	352	7.8%	4,520	75.3%	113	32.0%	1,448	24.1%
Summer presmolt (SWT)	3,069	34	7.1%	476	15.5%	16	46.0%	219	7.1%
Summer presmolt (EAG)	2,917	1	7.1%	14	0.5%	1	100.0%	14	0.5%
Pettit Lake									
Wild/natural smolt	—	1	7.7%	13	—	0	0.0%	0	—
Fall presmolt (SWT)	6,067	253	14.4%	1,756	28.9%	38	15.1%	265	4.4%
Summer presmolt (SWT)	3,092	19	12.2%	156	5.0%	1	5.3%	8	0.3%
Summer presmolt (EAG)	2,915	3	5.3%	57	2.0%	0	0.0%	0	—

* Total released for hatchery presmolts and smolts.
** Number of PIT-tagged fish in each group / number PIT tagged with confirmed 2-year-old smolts and mortalities removed.
*** Estimated from daily collection efficiency, actual counts for n = 1.
Data from Alturas and Pettit lake traps from SBT biologists.

Table 11. Median travel times of PIT-tagged sockeye salmon smolts recorded from outlet creek traps to mainstem Snake and Columbia river dams, Lower Granite (LGR), Little Goose (LGJ), Lower Monumental (LMN), and McNary (MCN) during 2001.

Release Strategy	Travel Time (Days)	LGR	LGJ	LMN	MCN
Redfish Lake					
Wild/natural	Median	10.3	19.6	—	—
	N	10	4	0	0
Fall direct presmolts	Median	10.6	15.4	20.3	16.0
	N	334	51	6	1
Alturas Lake					
Fall direct presmolts	Median	9.6	12	15.6	—
	N	94	14	5	0
Sawtooth reared summer	Median	10.3	13.8	—	—
	N	13	3	0	0
Pettit Lake					
Fall direct presmolts	Median	12.3	14.8	—	—
	N	32	3	0	0
Redfish Lake Creek					
Bonneville smolt	Median	12.2	15.2	16.7	—
	N	118	9	2	0

Table 12. Comparisons of distributions of PIT tag interrogations at Lower Granite Dam by release strategy for the 2001 out-migration year based on Kolmogorov-Smirnov two-sample tests ($\alpha = 0.10$).

Release Strategy	Wild/natural	Bonneville smolt	Redfish fall presmolt	Alturas fall presmolt	Alturas summer presmolt
Wild/natural					
Bonneville smolt	Significant				
Redfish fall presmolt	Not significant	Significant			
Alturas fall presmolt	Not significant	Significant	Significant		
Alturas summer presmolt	Not significant	Significant	Significant	Not significant	
Pettit fall presmolt	Not significant	Significant	Significant	Significant	Not significant

Table 13. Comparisons of PIT tag interrogations of sockeye salmon smolts PIT tagged at Sawtooth Basin trap sites and detected at Snake and Columbia river dams (Lower Granite, Little Goose, Lower Monumental and McNary) in 2001 ($\alpha = 0.10$). Smolt released to Redfish Lake Creek were PIT tagged prior to release.

Release Location	Release Strategy	Total PIT tagged	Cumulative Unique Interrogations	% Detected	χ^2 value	*P* value
Redfish Lake	wild/natural	39	14	35.9%		
Redfish Lake	fall direct presmolt	1390	393	28.3%	0.741	0.389
Redfish Lake	wild/natural	39	14	35.9%		
Pettit Lake	fall direct presmolt	253	35	13.8%	10.252	0.001
Redfish Lake	wild/natural	39	14	35.9%		
Alturas Lake	fall direct presmolt	352	113	32.1%	0.090	0.764
Redfish Lake	wild/natural	39	14	35.9%		
Redfish Lake Creek	smolt	1000	130	13.0%	14.600	<0.001
Redfish Lake	fall direct presmolt	1390	393	28.3%		
Redfish Lake Creek	smolt	1000	130	13.0%	78.476	<0.001
Redfish Lake	fall direct presmolt	1390	393	28.3%		
Pettit Lake	fall direct presmolt	253	35	13.8%	24.220	<0.001
Redfish Lake	fall direct presmolt	1390	393	28.3%		
Alturas Lake	fall direct presmolt	352	113	32.1%	1.816	0.177
Pettit Lake	fall direct presmolt	253	35	13.8%		
Alturas Lake	fall direct presmolt	352	113	32.1%	25.606	<0.001
Pettit Lake	fall direct presmolt	253	35	13.8%		
Redfish Lake Creek	smolt	1000	130	13.0%	0.061	0.804
Alturas Lake	fall direct presmolt	352	113	32.1%		
Redfish Lake Creek	smolt	1000	130	13.0%	63.150	<0.001

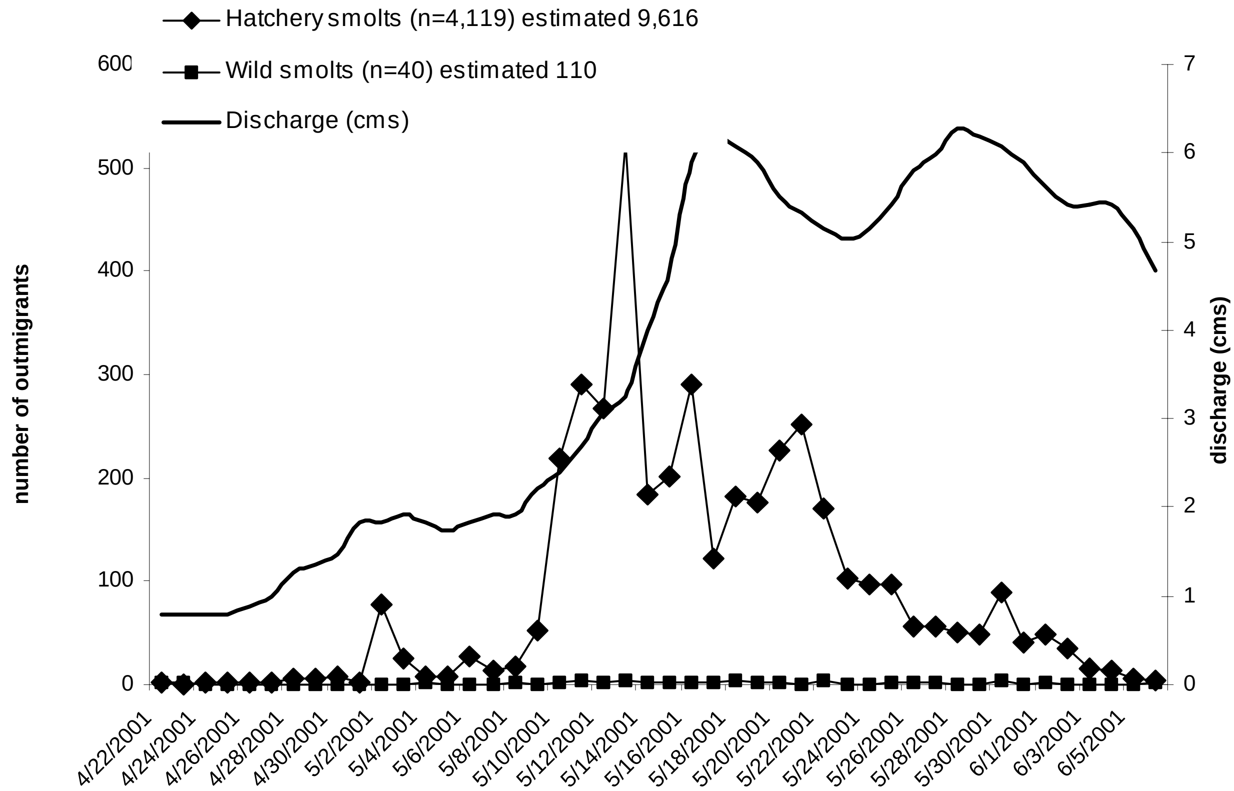

Figure 2. Daily capture of wild/natural and hatchery sockeye salmon smolts and discharge at the Redfish Lake Creek trap during the 2001 out-migration.

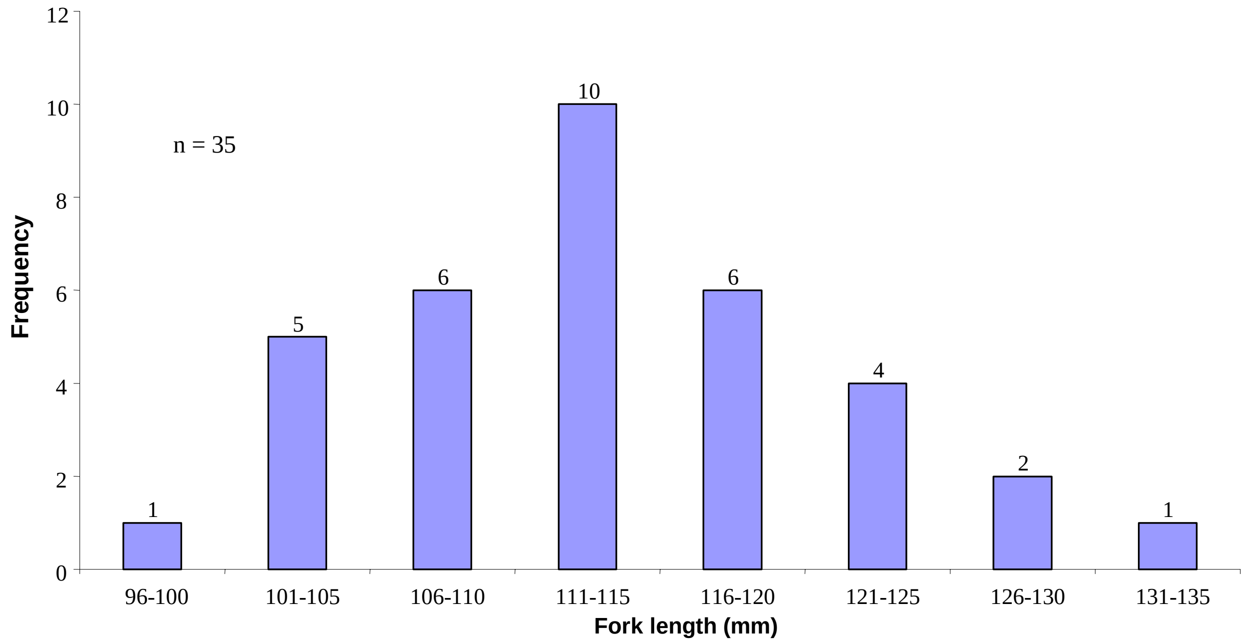

Figure 3. Length frequency of wild/natural smolts collected at Redfish Lake Creek Trap in 2001. Approximately 20% of wild/natural out-migrants were estimated to be age-2 (length greater than 120 mm). Total out-migration estimated at 110 smolts

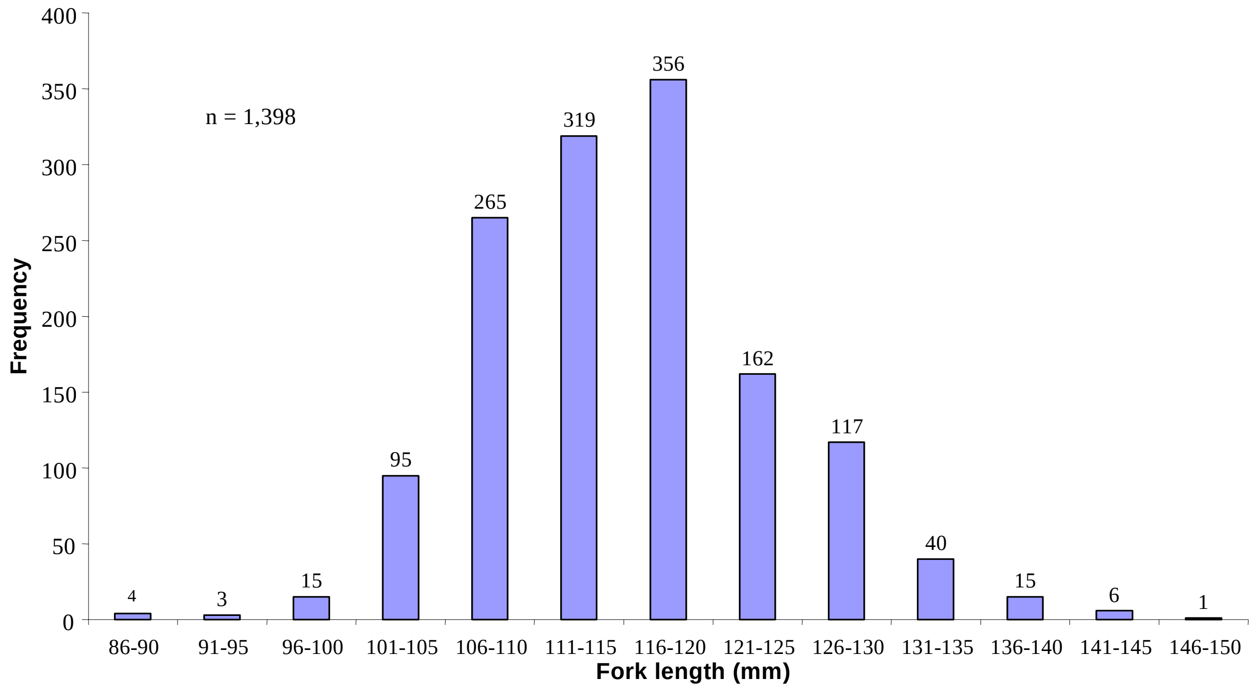

Figure 4. Length frequency of PIT-tagged hatchery-produced smolts captured at Redfish Lake Creek Trap in 2001. Total out-migration estimated at 9,616 smolts.

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PART 5—SOCKEYE SALMON SPAWNING INVESTIGATIONS

INTRODUCTION

Releasing mature adult sockeye salmon into Sawtooth basin lakes has been an important part of the spread-the-risk philosophy of the SBSTOC since fish from the captive broodstock program were first released back to the wild in 1993. Adult sockeye salmon raised to maturity in the hatchery and released to basin lakes to spawn provide a “natural” or unmarked smolt component that is subject to all the rigors and selection associated with the natural habitat. Beginning in 1999, returning adult hatchery-origin anadromous sockeye salmon have been released into basin lakes along with adult sockeye salmon that were raised to maturity in the hatchery. Current evaluations of adult sockeye salmon releases focus on the number of redds produced and estimations of unmarked juvenile out-migrants.

METHODS

On September 9 and 10, 2001, 65 hatchery-raised BY97 adult sockeye salmon and 14 anadromous adult sockeye salmon (seven females and seven males) were released to Redfish Lake (Table 13). All hatchery-raised adults were from NMFS Manchester Marine Laboratory. Efforts were made to release fish of equal sex ratios. Due to a lack of sexual dimorphism, sex of the hatchery-raised component could not be positively determined at time of release.

In order to identify spawning locations, six male and three female sockeye salmon were implanted with radio transmitters (two anadromous males, three hatchery-raised females, and four hatchery-raised males) prior to release. Telemetry investigations of adult locations began September 30, 2001 and continued weekly through November 7, 2001. Fish locations were recorded at least weekly by boat tracking.

RESULTS

The first area of excavation (possible redd) was located at the south end of the lake on October 23, 2001. Eleven excavation areas (possible redds) were located at the south end of the lake on the opposite shore from the U.S. Forest Service Transfer Camp dock. Aerial surveys conducted in November indicated another three areas of excavation near the inlet of Redfish Lake Creek at the south end of the lake (Table 14).

Five of the nine radio tags implanted in adult sockeye salmon were recovered during tracking efforts. None of the recovered tags were associated with carcasses, so it was impossible to determine if the fish had spawned. The first tag recovery was on October 11 on a hillside south of the Point Campground (NMFS-reared). The second and third tags were recovered on October 21 on the west shore of the lake south of the Point Campground (NMFS-reared) and near the U.S. Forest Service Transfer Camp dock (anadromous). The fourth and fifth tags were recovered on November 6 in Glacier View Campground (anadromous) and on the shore of the lake north of the U.S. Forest Service Transfer Camp dock (NMFS-reared).

DISCUSSION

Sockeye salmon spawning in Redfish Lake has been identified in three locations: Sockeye Beach, the south beach area near the slide, and the area near the U.S. Forest Service transfer camp dock. Sockeye Beach was named because of the congregations of spawning sockeye salmon that historically spawned there in October. The south beach spawning area was identified during field investigations in 1992 while searching for residual sockeye salmon. The U.S. Forest Service transfer camp dock was first identified as a spawning area associated with hatchery-raised adults released from the captive broodstock program.

Success of releasing hatchery-produced adults to spawn naturally will be determined by whether they increase the number of unmarked smolts out-migrating and observed egg to smolt survival. Because of the weir on Redfish Lake Creek, we have a good monitoring program for enumerating returning adults and out-migrating smolts. In 1998, 80 adults were released for natural spawning. We estimated subsequent smolt production to be about 150 age-1 smolts and 20 age-2 smolts. In 1999, only 21 adult sockeye salmon were released to Redfish Lake for natural spawning. We estimated the number of unmarked age-1 smolts was less than 100. Results from the age-2 out-migration in 2002 are needed to allow a more complete assessment of the production from the 1999 spawn year.

Currently we are working with the University of Idaho's Center for Salmonid and Freshwater Species at Risk to develop DNA microsatellite methods that will allow identification of individual parental contribution to unmarked smolt production. Although identifying redd construction and enumerating unmarked smolt out-migration are valuable parts of our natural spawning investigations, identification of the fish contributing progeny to the smolt out-migration will allow better evaluation and refinement of our adult rearing and release strategies.

Table 14. Redfish Lake Sockeye Salmon Captive Broodstock Program prespawn adult release history.

Lake	Rearing origin	Date released	Number released	Number of suspected redds
Redfish	Full-term hatchery	1993	20	Unknown
Redfish	Full-term hatchery	1994	65	One behavioral observation
Redfish	Full-term hatchery	1996	120	30 suspected redds
Redfish	Full-term hatchery	1997	80	30 suspected redds
Pettit	Full-term hatchery	1997	20	1 suspected redd
Alturas	Full-term hatchery	1997	20	Test digs only
Redfish	Full-term hatchery	1999	18	
Redfish	Hatchery-produced anadromous	1999	3	8 suspected redds
Redfish	Full-term hatchery	2000	36	
Redfish	Hatchery-produced anadromous	2000	120	20 to 30 suspected redds
Pettit	Hatchery-produced anadromous	2000	28	None confirmed
Alturas	Full-term hatchery	2000	25	
Alturas	Hatchery-produced anadromous	2000	52	14 to 19 suspected redds
Redfish	Hatchery-produced anadromous	2001	14	
Redfish	Full-term hatchery	2001	65	12 to 15 suspected redds
		Total	**686**	

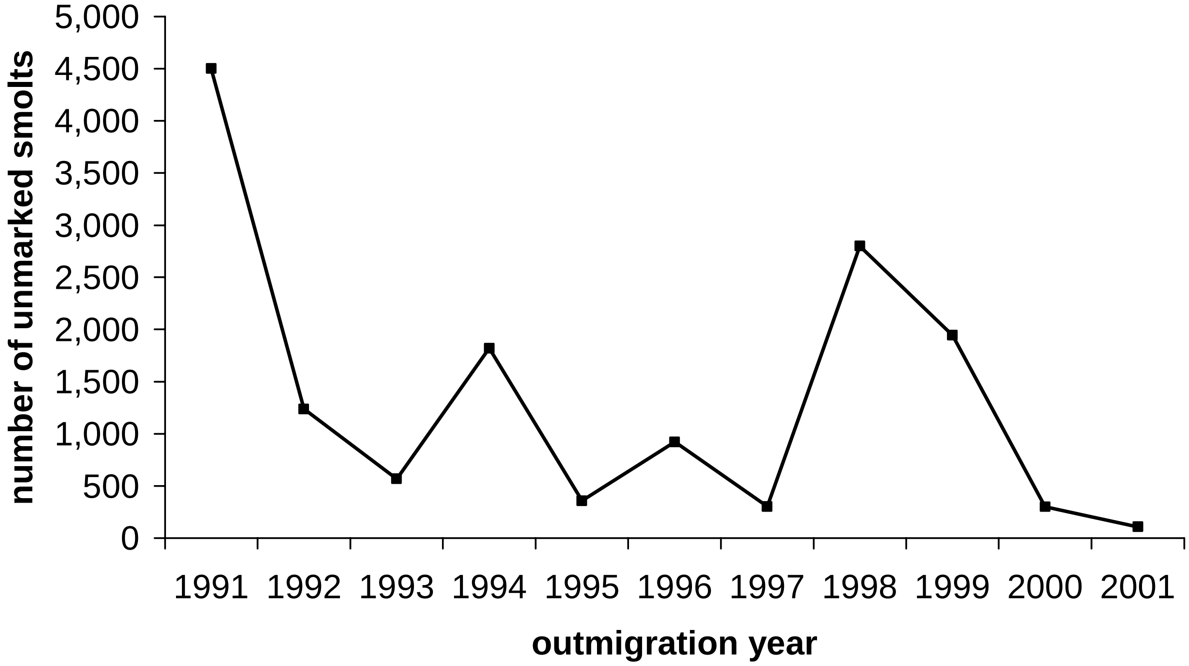

Figure 5. Wild/natural sockeye salmon smolt out-migration estimated at Redfish Lake Creek Trap from 1991 to 2001.

PART 6—PARENTAL LINEAGE INVESTIGATIONS

INTRODUCTION

The ability to discern the origin of unmarked returning adult sockeye salmon is vital to our ability to use anadromous adults within the captive broodstock program. Since 1999, hatchery-produced adult sockeye salmon have been returning to the Sawtooth basin. Juvenile sockeye salmon are marked with fin clips before release; however, returning adult sockeye salmon that are unmarked could be the progeny of natural spawning adults (anadromous or hatchery-produced), eyed-egg plants, or residual sockeye salmon spawning.

Early in the captive broodstock program, otolith microchemistry was used to improve our knowledge of the life history of wild sockeye salmon that were captured and spawned in the captive broodstock program (Kline 1994; Kline and Younk 1995; Kline and Lamansky 1997). Specifically, otolith microchemistry was used to determine if returning adult sockeye salmon were the progeny of anadromous sockeye salmon or residual sockeye salmon. However, because extracting an otolith is a lethal process, it has been used only on sockeye salmon that were incorporated into the captive broodstock program. This lethal sampling reduces the usefulness of the technique for large application with this endangered stock.

Currently we are working with the University of Idaho's Center for Salmonid and Freshwater Species at Risk to develop nonlethal genetic techniques to identify the parental lineage of an individual sockeye salmon from the captive broodstock program. This nonlethal test will allow us to evaluate the contribution of the eyed-egg or hatchery-adult outplants to unmarked smolt production. In addition, the test will be used to identify returning unmarked adult sockeye salmon to allow us to maximize their use in the captive breeding program.

METHODS

In 2001, all sockeye salmon spawned in the captive broodstock program had fin tissue collected and archived in Lysis buffer solution for genetic analysis. In addition to the fin tissue, all nine anadromous adults that were returned to the hatchery and spawned in the captive broodstock program had their otoliths removed and archived. All adults released to Redfish Lake for natural spawning had fin tissue collected and archived.

We have 34 otoliths polished and mounted according to methods described by Kalish (1990) and Rieman et al. (1993). The otoliths are from 16 hatchery and eight wild sockeye salmon smolts collected at Redfish Lake Creek Trap in 1999, four smolts collected at RLCTRP in 1998, four anadromous hatchery adults from 1999, and the remaining otolith from the lone adult that returned in 1998.

RESULTS

Otolith microchemistry analysis is pending.

Genetic analysis is pending.

DISCUSSION

The ability to identify release strategies that produce unmarked out-migrants has confounded investigators since this program started. The only way to identify the smolt production from an individual release strategy that produces unmarked smolts has been to separate the release strategies between lakes. Although this allows us to estimate smolt production from a given release strategy, it reduces our flexibility in relation to using the lake with the best rearing environment at the current time (high zooplankton densities, low kokanee biomass). This tool will also allow us to compare smolt production from hatchery-produced adult outplants to that of anadromous returning adults.

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PART 7—PREDATOR SURVEYS

INTRODUCTION

Declines in bull trout populations throughout the Pacific Northwest led to their listing as threatened under the Endangered Species Act in 1998. Prior to listing, IDFG implemented no-harvest fishing regulations to help protect the remaining populations in the state of Idaho. Because bull trout readily consume kokanee and other salmonids (Bjornn 1961; Beauchamp and Van Tassell 2001), a large increase in the number of adult bull trout in the lake could affect the sockeye salmon and kokanee populations in the lake.

METHODS

Monitoring of spawning bull trout was initiated in 1995 to measure bull trout population response to no-harvest fishing regulations implemented by IDFG in 1994. In 2000, we surveyed index reaches, which were established in 1998, on principal tributary streams of Redfish and Alturas lakes to enumerate bull trout spawners and redds. Surveys were conducted on Fishhook Creek (Redfish Lake drainage) and Alpine Creek (Alturas Lake drainage) on August 28 and September 11. Index sections were established with global positioning satellite (GPS) equipment. Two observers walked from the lower boundary of the index section upstream and recorded visual observations of bull trout and known or suspected bull trout redds. Coordinates of redd locations were recorded with a GPS unit.

RESULTS

<u>Fishhook Creek</u>

We observed 31 adult bull trout and 15 completed redds on August 28. Water temperature at 1724 hours was 12.0°C. During our second survey, September 11, we observed three adult bull trout and 11 completed redds. Water temperature was 8.0°C at 1654 hours. Redd counts on the second date were not cumulative with previous count (Table 15).

<u>Alpine Creek</u>

We observed eight adult bull trout and 15 completed redds during the August 28 survey. Water temperature was not recorded during this survey. On September 11, we observed three adult bull trout and 11 completed redds. Water temperature was 7.5°C at 1145 hours during the second survey. Redd counts on the second date were not cumulative with previous count (Table 16).

DISCUSSION

Bull trout spawner investigations were initiated in 1995 to track population response to no-harvest fishing regulations implemented by IDFG in 1994. Trend data of this nature have been successfully used to measure population response to fishing regulation changes implemented for adfluvial bull trout populations in Oregon and British Columbia (Ratliff 1992; Stelfox and Egan 1995).

Final index sections were established on Fishhook and Alpine creeks in 1998. Information collected in 2001 represented the fourth year data were collected in these index reaches.

From the four years of data, it appears that the no-harvest fishing regulation is affecting the bull trout population in Alpine Creek more than in Fishhook Creek. The Alpine Creek population has increased steadily since 1998, beginning with one redd and reaching a high of 15 redds. Redd counts in Fishhook Creek have been holding constant since 1998, varying between 11 and 18 redds counted each year. Because bull trout may spawn in alternating or consecutive years (Fraley and Shepard 1989) year-to-year variation would be expected. The effects of no-harvest regulations may take several more years to become apparent, because bull trout generally mature at five to six years of age (Leary et al. 1993), and only one cohort has been completely removed from potential harvest by anglers.

This effort represented the only attempt to monitor bull trout populations in the upper Salmon River drainage upstream of the Lemhi River (Tom Curet, IDFG, personal communication). Monitoring bull trout populations with redd counts is advantageous, because they are low cost and cause little disturbance to spawning bull trout. However, several sources of error are associated with counting redds. True redds may be missed (omissions) due to location in the stream (associations with depth or cover) or natural channel formations may be counted as redds (false identifications). In addition to the observation error, sampling index sections provide accurate counts only if the distribution of spawning does not change from year to year (Rieman and Meyers 1997; Dunham et al. 2001).

We believe that our counts of redds in the trend sections were an accurate reflection of the numbers of redds present. The streams in our surveys were much smaller than those used by Dunham et al. (2001). As an example, in the systems studied by Dunham et al. (2001) deepwater cover was defined as water greater than 1 m deep. In Fishhook and Alpine creeks, water depth rarely approached 1 m deep. Our 2001 data did indicate that redds enumerated during the first count may have been omitted from the second count, as evidenced by the higher redd numbers during the first count. In order to avoid omission of completed redds during the final count, completed redds identified during the first count should be flagged. Flagging would allow evaluation of the potential for omitting redds from the final count that were obscured over time. Another way to improve the usefulness of our redd count data would be to periodically (every 4-5 years) survey the entire drainage for spawning activity during the same time periods that index reaches are surveyed and determine if the proportion of spawning that is taking place in the index reaches remains constant.

Table 15. Bull trout adult fish counts and redd counts in trend survey sections of Fishhook Creek from 1998 to 2001.

Date	Bull Trout	Number of Redds
1998		
8/22	40	5
9/10	2	11
1999		
8/22	40	0
8/26	33	15
2000		
8/31	16	12
9/14	2	18
2001		
8/28	31	15
9/11	3	11

Table 16. Bull trout adult fish counts and redd counts in trend survey sections of Alpine Creek from 1998 to 2001.

Date	Bull Trout	Number of Redds
1998		
8/23	6	0
9/11	6	1
1999*		
8/26	13	3
2000		
8/30	18	6
9/15	5	9
2001		
8/28	8	15
9/11	3	10

* only one count completed

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APPENDICES

Appendix A. Fork length and weight (g) of kokanee captured during midwater trawls conducted during September 2001 on Redfish, Pettit, Alturas, and Stanley lakes.

Transect	Length (mm)	Weight (g)
	Redfish Lake	
1	74	4.1
1	66	2.5
1	83	5.2
2	107	12.2
3	48	1.0
3	66	2.6
3	89	6.7
4	65	2.8
4	67	2.9
4	87	6.3
4	80	5.1
4	73	3.5
4	81	5.1
4	72	3.3
4	72	3.4
6	65	2.6
	Pettit Lake	
1	173	51.1
1	175	53.8
1	182	55.6
1	187	75.8
1	185	58.4
1	171	55.7
2	171	53.1
2	177	57.1
2	186	71.5
2	180	60.4
2	184	74.4
2	180	60.6
2	173	55.9
3	183	69.0
3	184	79.2
3	170	56.9
3	183	56.8
3	171	46.7
3	180	50.8
3	171	49.9
3	171	51.7
3	184	74.0
3	182	56.2
3	183	57.2
3	183	54.2
3	86	7.4
4	176	55.4
4	173	48.9
4	190	63.6
4	173	55.3

Appendix A, continued.

Transect	Length (mm)	Weight (g)
	Alturas Lake	
1	50	0.7
1	49	0.9
1	54	1.2
1	54	1.2
1	69	2.7
1	73	2.9
1	76	3.7
1	77	3.9
1	74	3.5
1	82	4.8
1	82	4.7
1	90	6.2
1	96	6.8
1	98	7.6
1	94	8.1
1	110	11.5
1	111	11.9
1	119	14.5
1	115	13.3
1	121	17.0
1	130	19.2
1	159	28.4
2	49	1.0
2	64	2.2
2	72	3.1
2	74	3.9
2	74	3.3
2	76	3.5
2	80	4.9
2	89	6.8
2	94	7.6
2	94	7.0
2	99	9.3
2	109	11.6
2	114	12.6
2	122	16.3
2	117	14.4
2	108	11.0
2	120	14.6
2	116	13.3
2	118	14.7
2	115	13.3
2	126	17.1
2	128	18.2
2	123	15.3
2	128	18.4
2	138	23.5
2	156	30.4
2	147	27.8
2	162	34.5
2	160	32.5
3	47	1.2

Appendix A, continued.

Transect	Length (mm)	Weight (g)
3	66	2.8
3	67	3.1
3	68	3.0
3	76	3.8
3	76	3.8
3	74	3.2
3	72	2.9
3	75	3.0
3	78	3.9
3	81	4.4
3	78	3.9
3	75	3.5
3	80	4.3
3	83	5.2
3	81	4.3
3	93	7.2
3	87	5.9
3	92	6.6
3	89	6.3
3	94	7.3
3	98	8.8
3	101	8.9
3	110	12.3
3	105	10.9
3	127	18.3
3	125	19.1
3	123	16.1
3	135	19.3
3	133	20.4
3	135	20.4
3	143	24.4
3	155	31.4
3	167	37.1
4	53	1.2
4	54	1.2
4	65	2.5
4	75	3.2
4	79	4.2
4	85	5.0
4	95	7.2
4	95	7.9
4	96	7.6
4	104	10.3
4	135	19.5
4	134	20.3
4	140	22.8
4	157	27.3
4	143	26.4
4	156	32.8
4	153	30.2
4	161	33.6
4	113	12.9
4	125	15.8

Appendix A, continued.

Transect	Length (mm)	Weight (g)
4	113	12.2
4	120	15.8
4	115	14.8
4	122	15.7
4	116	12.8
4	110	12.6
4	122	16.3
4	110	13.4
4	115	13.0
4	116	10.8
4	110	11.9
	Stanley Lake	
1	72	5.0
1	91	7.3
1	103	10.4
1	90	8.0
1	87	7.1
1	62	3.1
1	57	1.7
1	81	5.9
2	58	2.0
2	90	7.4
4	95	9.4
4	77	4.7

Appendix B. Arrival dates for PIT-tagged sockeye salmon smolts at Lower Granite Dam for the 2001 migration year.

Date	Bonneville Smolt Release	Redfish Lake		Alturas Lake		Pettit Lake Fall Release
		Wild/Natural	Fall Release	Fall Release	Summer Release	
5/11/01			2			
5/12/01	1			1		
5/13/01	6		3			
5/14/01	7		1			
5/15/01	19		5	1		
5/16/01	27	1	8	8	1	
5/17/01	13		11	7	1	
5/18/01	10		21	9		
5/19/01	16	1	20	12	2	2
5/20/01	7	2	16	7	3	4
5/21/01	2	1	12	6	1	4
5/22/01	3		17	9	1	8
5/23/01			14	5	2	
5/24/01	1		12	6		3
5/25/01			14	4		
5/26/01	2		21	6	1	4
5/27/01			10	3	1	1
5/28/01	1	1	9	2		1
5/29/01		2	16	2		
5/30/01			3	1		
5/31/01			2	1		
6/1/01		1	5	1		
6/2/01			6			
6/3/01			9	1		1
6/4/01			5			
6/5/01			12			1
6/6/01			6	1		
6/7/01			9			
6/8/01			6			1
6/9/01	1	1	3	1		
6/10/01			3			1
6/11/01			5			
6/12/01	1		7			
6/13/01			8			
6/14/01			7			
6/15/01			4			
6/16/01			5			1
6/17/01			1			
6/18/01			2			
6/19/01			1			
6/20/01			1			
6/21/01			1			
6/22/01			1			
6/23/01						
6/24/01						
6/25/01						
6/26/01						
6/27/01						
6/28/01						

Appendix B, continued.

Date	Bonneville	Redfish Lake		Alturas Lake		Pettit Lake
	Smolt Release	Wild/Natural	Fall Release	Fall Release	Summer Release	Fall Release
6/29/01						
6/30/01						
7/1/01						
7/2/01						
7/3/01						
7/4/01						
7/5/01						
7/6/01	1					
7/7/01			1			
7/8/01						
7/9/01						
7/10/01						
7/11/01						
7/12/01			1			
7/13/01						
7/14/01						
7/15/01						
7/16/01						
7/17/01						
7/18/01						
7/19/01						
7/20/01						
7/21/01			1			
Total	**118**	**10**	**327**	**94**	**13**	**32**

Appendix C. Estimates of PIT-tagged sockeye salmon passing Lower Granite Dam for the 2001 migration year. Actual PIT tag interrogations are expanded by Daily Collection Efficiency. Flow and spill are in KCFS. Groups are abbreviated as follows: Bonneville smolt release (SMT), Redfish Lake wild/natural smolts (RFL WN), Redfish Lake fall presmolt (RFL Fall), Alturas Lake fall presmolt (ALT Fall), Alturas summer presmolt (ALT Sum), Pettit Lake fall presmolt (PET Fall).

Date	DCE	Flow	Spill	SMT	RFL WN	RFL Fall	ALT Fall	ALT Sum	PET Fall	Cumulative
5/11/01	0.851	55.8	0	0	0	2	0	0	0	2
5/12/01	0.845	55.6	0	1	0	0	1	0	0	5
5/13/01	0.842	61.9	0	7	0	4	0	0	0	15
5/14/01	0.836	70.9	0	8	0	1	0	0	0	25
5/15/01	0.837	84.7	0	23	0	6	1	0	0	55
5/16/01	0.840	91.3	0	32	1	10	10	1	0	108
5/17/01	0.825	88.3	0	16	0	13	8	1	0	147
5/18/01	0.823	81.9	0	12	0	26	11	0	0	196
5/19/01	0.824	75.3	0	19	1	24	15	2	2	260
5/20/01	0.826	68.3	0	8	2	19	8	4	5	307
5/21/01	0.828	62.8	0	2	1	14	7	1	5	339
5/22/01	0.834	60.0	0	4	0	20	11	1	10	384
5/23/01	0.834	62.4	0	0	0	17	6	2	0	409
5/24/01	0.833	64.2	0	1	0	14	7	0	4	436
5/25/01	0.840	69.9	0	0	0	17	5	0	0	457
5/26/01	0.844	75.5	0	2	0	25	7	1	5	498
5/27/01	0.845	67.0	0	0	0	12	4	1	1	515
5/28/01	0.858	65.9	0	1	1	10	2	0	1	532
5/29/01	0.845	63.8	0	0	2	19	2	0	0	555
5/30/01	0.847	59.7	0	0	0	4	1	0	0	560
5/31/01	0.841	54.5	0	0	0	2	1	0	0	564
6/1/01	0.854	51.8	0	0	1	6	1	0	0	572
6/2/01	0.877	47.7	0	0	0	7	0	0	0	579
6/3/01	0.844	43.7	0	0	0	11	1	0	1	592
6/4/01	0.846	43.1	0	0	0	6	0	0	0	598
6/5/01	0.860	43.4	0	0	0	14	0	0	1	613
6/6/01	0.868	41.4	0	0	0	7	1	0	0	621
6/7/01	0.860	42.1	0	0	0	10	0	0	0	631
6/8/01	0.860	45.7	0	0	0	7	0	0	1	639
6/9/01	0.881	45.7	0	1	1	3	1	0	0	646
6/10/01	0.874	38.2	0	0	0	3	0	0	1	651
6/11/01	0.853	39.0	0	0	0	6	0	0	0	657
6/12/01	0.863	39.4	0	1	0	8	0	0	0	666
6/13/01	0.837	41.6	0	0	0	10	0	0	0	675
6/14/01	0.836	38.2	0	0	0	8	0	0	0	684
6/15/01	0.830	37.8	0	0	0	5	0	0	0	689
6/16/01	0.833	37.6	0	0	0	6	0	0	1	696
6/17/01	0.845	34.9	0	0	0	1	0	0	0	697
6/18/01	0.843	33.3	0	0	0	2	0	0	0	699
6/19/01	0.811	30.4	0	0	0	1	0	0	0	701
6/20/01	0.869	31.9	0	0	0	1	0	0	0	702
6/21/01	0.855	27.8	0	0	0	1	0	0	0	703
6/22/01	0.897	30.4	0	0	0	1	0	0	0	704
6/23/01	0.874	26.7	0	0	0	0	0	0	0	704
6/24/01	0.880	20.5	0	0	0	0	0	0	0	704
6/25/01	0.832	29.5	0	0	0	0	0	0	0	704
6/26/01	0.770	29.6	0	0	0	0	0	0	0	704
6/27/01	0.832	24.2	0	0	0	0	0	0	0	704
6/28/01	0.832	26.0	0	0	0	0	0	0	0	704
6/29/01	0.912	27.9	0	0	0	0	0	0	0	704
6/30/01	0.832	22.9	0	0	0	0	0	0	0	704

Appendix C, continued.

Date	DCE	Flow	Spill	SMT	RFL WN	RFL Fall	ALT Fall	ALT Sum	PET Fall	Cumulative
7/1/01	0.824	23.6	0	0	0	0	0	0	0	704
7/2/01	0.751	24.9	0	0	0	0	0	0	0	704
7/3/01	0.813	25.1	0	0	0	0	0	0	0	704
7/4/01	0.787	26.3	0	0	0	0	0	0	0	704
7/5/01	0.813	25.4	0	0	0	0	0	0	0	704
7/6/01	0.872	29.3	0	1	0	0	0	0	0	705
7/7/01	0.767	26.2	0	0	0	1	0	0	0	707
7/8/01	0.838	27.9	0	0	0	0	0	0	0	707
7/9/01	0.832	25.5	0	0	0	0	0	0	0	707
7/10/01	0.771	25.2	0	0	0	0	0	0	0	707
7/11/01	0.700	26.0	0	0	0	0	0	0	0	707
7/12/01	0.744	28.4	0	0	0	1	0	0	0	708
7/13/01	0.804	26.3	0	0	0	0	0	0	0	708
7/14/01	0.783	27.5	0	0	0	0	0	0	0	708
7/15/01	0.967	24.0	0	0	0	0	0	0	0	708
7/16/01	0.832	24.4	0	0	0	0	0	0	0	708
7/17/01	0.832	29.0	0	0	0	0	0	0	0	708
7/18/01	0.874	25.2	0	0	0	0	0	0	0	708
7/19/01	0.921	27.6	0	0	0	0	0	0	0	708
7/20/01	0.832	26.9	0	0	0	0	0	0	0	708
7/21/01	0.832	27.0	0	0	0	1	0	0	0	709
		Totals		**142**	**12**	**389**	**113**	**16**	**38**	

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